In-depth Q&A: Three researchers on the front line of today's gravitational wave discovery

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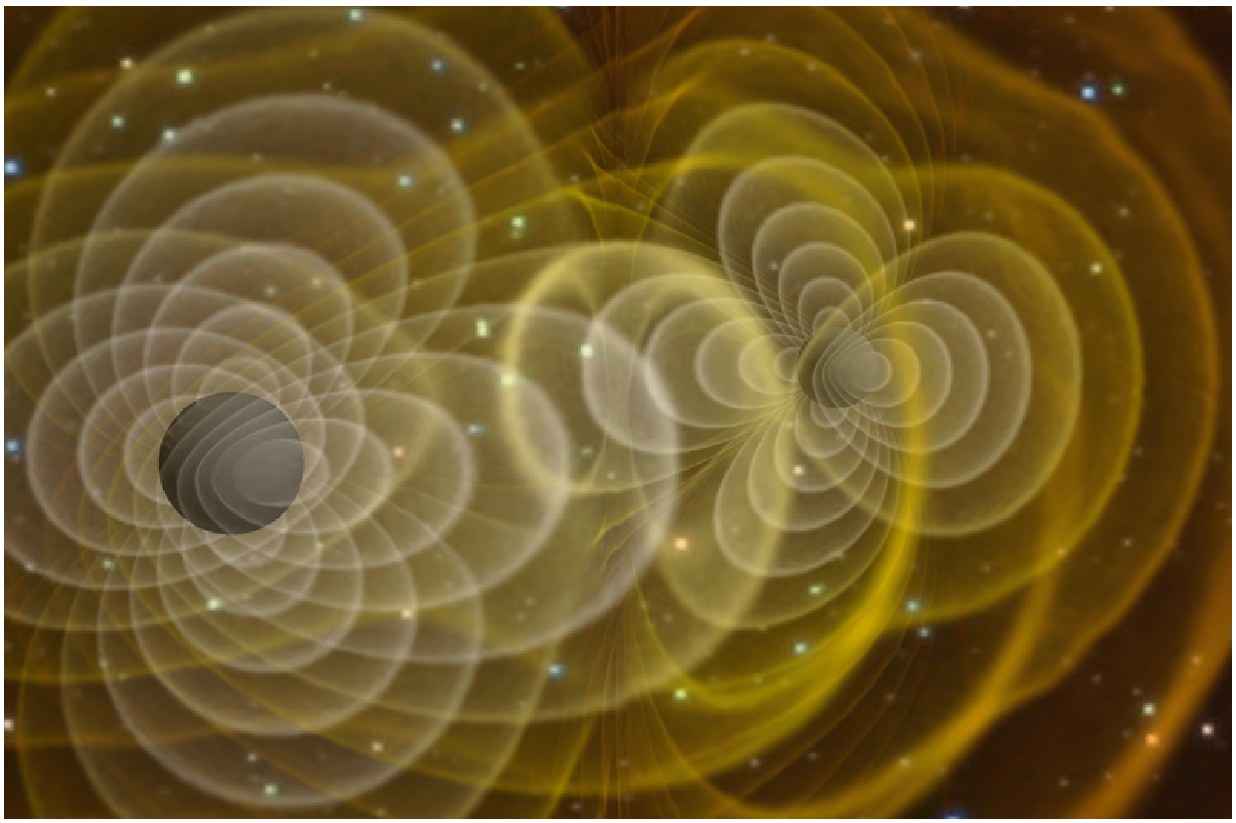

A visualization of a supercomputer simulation of merging black holes sending out gravitational waves. Credit: NASA/C. Henze

News broke earlier today that elusive ripples in space-time—known as gravitational waves—have been detected for the first time here on Earth by the Laser Interferometer Gravitational Wave Observatory (LIGO).

To get behind the scenes of this major discovery, The Kavli Foundation hosted an exclusive roundtable discussion with three key LIGO researchers, who are all part of the Massachusetts Institute of Technology Kavli Institute for Astrophysics and Space Research (MKI).

The panel discussed how studying gravitational waves will push Albert Einstein's General Theory of Relativity—which originally predicted their existence almost exactly a century ago—to its limits, while revolutionizing our understanding of the most violent events in the universe.

"I keep telling people I'd love to be able to see Einstein's face right now!" said Rainer Weiss, an emeritus professor of physics at the Massachusetts Institute of Technology (MIT) and a member of MKI. "All of sudden with LIGO, we're dealing with a regime where Einstein's equations had never been applied before."

Weiss was among the first to explore the kind of instrumentation necessary to detect gravitational waves back in the 1970s. He later proposed the LIGO project with two colleagues from the California Institute of Technology in the 1980s. The project was funded by the National Science Foundation and started its first observing run in 2002. Following major upgrades begun in 2010, LIGO re-opened as "Advanced LIGO" in September 2015 and detected its first gravitational waves within days.

Analysis of the waves suggests they originated from a system of two black holes, each with the mass of about 30 Suns, that gravitationally drew closer to each other. The dense objects whipped up to nearly the speed of light before colliding, sending out a stupendous release of gravitational wave energy that eventually reached the Earth, 1.5 billion light years away.

As the gravitational waves warped space-time within LIGO's gargantuan, twin detectors, its exquisitely sensitive instruments registered vibrations on the order of thousands of the diameter of a proton. The frequency of these waves that LIGO is designed to catch are actually in the audible range for humans. Accordingly, the signal LIGO received of the black hole merger was played on speakers to audiences of eager scientists.

"For this binary black hole system, it made a distinctive, rising 'whoooop!' sound," said Matthew Evans, an assistant professor of physics at MIT as well as a member of MKI. "This detection means that the stars are no longer silent . . . It's not that we just look up and see anymore, like we always have—we actually can listen to the universe now. It's a whole new sense, and humanity did not have this sense until LIGO was built."

To date, virtually all of our knowledge of the cosmos has come from observing electromagnetic radiation, better known as light, including radio waves, visible light and gamma rays. Now, with the advent of gravitational wave astronomy, otherwise invisible phenomena, such as the black hole system captured by LIGO, will be accessible.

"We could point the best telescopes, sensitive to more or less any electromagnetic wavelength of light, at this system and probably see nothing," said Nergis Mavalvala, a professor of astrophysics at MIT and also a member of MKI. "We cannot observe this system with any of the other fundamental forces of nature. It has to be gravity."

More information: Read the full conversation with Rainer Weiss, Matthew Evans and Nergis Mavalvala on The Kavli Foundation website: www.kavlifoundation.org/scienc … veal-hidden-universe

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